Development of Air Force Applications for Hydrothermal Oxidation Technology

An innovative, versatile, and cost-effective waste management option
to improve the overall operation efficiencies of the US Air Force

HYDROTHERMAL OXIDATION

Hydrothermal Oxidation (HTO), also known as Supercritical Water Oxidation (SCWO), has become a viable and economical technology for converting hazardous materials and wastes to benign compounds. Hydrothermal oxidation has been demonstrated to treat a wide range of organic wastes and energetic materials generated by weapon system sustainment and demilitarization operations. HTO is a simple, safe, closed-loop treatment process in which organic wastes are mixed with water and an oxidizer, pressurized to above 3500 psi, and heated to at least 750^{o}F (critical point of water).

Above the critical point, water acts as an effective "organic" solvent and has much higher heat- and mass-transfer coefficients than conventional combustion processes. The oxidation proceeds rapidly in a homogeneous, or slightly heterogeneous, phase consisting of supercritical water, organic compounds, and oxygen. Complete oxidation is accomplished within residence times of a few seconds to minutes depending on the waste being treated. Wastes are converted to carbon dioxide, water, and inorganic acids/salts. Since HTO is operated at much lower temperatures than that for incineration, NO_x formation is minimized. With proper thermal management, HTO not only achieves self-sustained chemical reaction but also generates residual heat that can be utilized for secondary energy generation.

ENGINEERING DEVELOPMENT

HTO has evolved from the laboratory to industrial-scale applications. Initial R&D efforts in the early 1980s demonstrated the efficacy of HTO technology for treating a variety of toxic organic wastes. In 1990, the Air Force Research Laboratory (AFRL/MLQE), Tyndall AFB, FL, and its prime contractor, General Atomics (San Diego, CA), developed a program to take HTO technology from the bench, perform the necessary engineering development, and demonstrate the use of the technology to destroy propellant from ICBM rocket motors.

There were two major technical challenges in designing a SCWO system for the destruction of the propellant from ICBM rocket motors. First, the process had to be able to withstand the corrosive environment at supercritical water conditions with high-concentrations of chloride from ammonium perchlorate (a major propellant constituent). Second, the process had to be able to transport solids through the system without fouling and plugging the reactor, heat-exchangers, and pressure letdown operations.

GREATER THAN 99% CONVERSION

Under a joint effort with AFRL/MLQE, General Atomics, and the Joint Ordnance Commanders Group (JOCG), who provided development funding, a pilot-scale system was designed, built, and tested at a rocket motor production facility in Utah. Approximately 700 pounds of Hazard Class 1.1 rocket propellant was hydrolyzed and converted to benign compounds (*i.e.*, carbon dioxide, water, inorganic salts, and aluminum oxide) by hydrothermal oxidation. In addition, the HTO process achieved greater than 99.99% destruction efficiency.

FUTURE APPLICATION

AFRL/MLQ has initiated a development program to use HTO on wastes generated from Air Logistic Center (ALC) weapons system support operations. These wastes include paint stripping wastes, mixed organics, solids and sludges, oil-water mixtures and emulsions, toxic chemicals, and other hazardous wastes. This effort leverages and builds upon systems under development by the Army (ARDEC) and the Navy (ONR) for treatment of service specific hazardous wastes. Next generation HTO reactor systems are being developed at AFRL/MLQ. The goal is to provide simple, robust and reliable HTO reactor systems for on-site demonstration at various ALC locations. HTO has reached commercial maturity because these systems can be designed, built, and installed with existing waste treatment processes. Future research and development will establish hydrothermal oxidation technology for the elimination of other wastes generated by military and industrial operations.

PAYOFF

Typical waste treatment cost for HTO is less than $0.10/lb, making the HTO process very competitive with other treatment alternatives. Based on a waste treatment cost of $0.25/lb, the payback period for a 2.0 gallon-per-minute HTO system is less than 3 years. Since the HTO technology produces benign effluents and significant amounts of excess heat (steam), secondary energy recovery may provide additional operational value to the hydrothermal oxidation reactor process.

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